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Colonization.
Evidence of Mr. Frank T. Shutt...
1897 & 1898.

WITH MR. SHUTT'S COMPLIMENTS

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CHEMIST OF THE DOMINION EXPERIMENTAL FARMS

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SELECT STANDING COMMITTEE OF THE HOUSE OF COMMONS

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COMMITTEE ROOM 46,
HOUSE OF COMMONS, Friday, 11th June, 1897.

The Select Standing Committee on Agriculture and Colonization met this day at 10 a.m., Mr. Bain, Chairman, presiding.

Mr. FRANK T. SHUTT, Chief Chemist of the Dominion Experimental Farms, was present by request, and being called, addressed the Committee as follows :—

Mr. CHAIRMAN AND GENTLEMEN,—On former occasions when I have had the honour of addressing you upon the work of the Chemical division of the experimental farms, I have endeavoured to explain, or at least to outline, the intimate relationship that exists between chemistry and agriculture. I have pointed out that the terms scientific agriculture and agricultural chemistry are almost synonymous. By scientific agriculture I mean farming conducted with a knowledge of the natural laws which affect and govern plant and animal life and inert matter. There are indeed very few problems that meet the practical farmer that do not call for some assistance from chemistry. Whether it is a question of determining the plant food in soils, the feeding value of fodder or the quality of a fertilizer, they all require for their solution the aid of chemistry. It is therefore apparent that the work covered by the department of chemistry at the experimental farms covers a wide and, necessarily, varied range. The scope of our investigations is only limited by the opportunities that we have, and consequently it would be impossible for me this morning to even mention many of the experiments that have been conducted, and the interesting facts that have been ascertained by us during the past year. The work, in general, has been carried on, on very much the same lines as in former years. If time permits, I propose to say just a few words respecting each of the more important investigations that have been pursued.

VIRGIN SOILS.

With respect to the examination of Canadian virgin soils, we have added somewhat to our knowledge. The data that we have accumulated are altogether too voluminous for me now to enter into or discuss in detail, but they appear in the report which is now in press. Some of the samples which have been examined were collected in the Cariboo District of British Columbia. That is an area which, as you are aware, has been especially looked upon as a mining area ; it is a practically unsettled and uncropped area. The object of the examination was to ascertain what the probable fertility of the soil in that district might be, so that we could estimate the future possibilities of the district as an agricultural area for grazing or mixed farming. You will doubtless be gratified to learn that the district may eventually be something more than it is now, a prosperous mining district, because I have been able to conclude from a chemical and physical examination of the soils that have been sent from there that, though the soils, as a rule, are light in character, there are many of them which possess an abundance of plant food, —both of nitrogen and mineral constituents. Others of the soils from that area that we examined were thin and poor, and certainly would require the most favourable climatic conditions in order to yield good crops.

THE EXAMINATION OF CULTIVATED SOILS FOR FARMERS.

Besides the soils which were submitted to complete analysis, many samples of cultivated soils, received from farmers in Ontario and Quebec and in the maritime provinces, have been subjected to a partial analysis, which usually consisted of a determination of the humus, nitrogen and lime, and the relative proportions of clay and sand. This work,

owing to the very numerous demands made for soil diagnosis, has entailed a considerable expenditure of time; but I think the results, and the suggestions that we have been able to make from the results, have proved so useful that it would be advisable, for the present, at any rate, to continue it. The analysis of these cultivated, and what we might call partially exhausted soils, shows that we have many soils in Canada which, though giving poor returns, have by no means been depleted of their plant food. This plant food, however, is "locked up," and what is specially needed is more thorough tillage in order to render that plant food more available, and that is the opinion reached after the examination of a considerable number of samples. We need to draw the attention of farmers not only to the use of manures and fertilizers, but also to correct tillage. They should be instructed in the reasons for ploughing and harrowing, etc., and taught that a good mechanical condition of the soil is necessary, in order that the plants may find a good and comfortable seed and root bed, and that the soil be able to conserve moisture during seasons of drought. I am convinced that many of our cultivated soils could be vastly improved in productive power, simply by tillage of a more thorough and rational character. The reasons for drainage, ploughing, cultivating, etc., should be well understood and carried out, for it is by such means that not only the best mechanical condition and ratio of moisture of the soil is secured, but that the stores of locked up plant food are rendered available.

By Mr. McMillan:

Q. What is the first step to be taken?

A. That would depend upon the character of the soil; if a heavy soil, drainage would be of primary importance; then deep ploughing at the proper season when the soil is not wet, such ploughing as would thoroughly disintegrate the mass. Then the fining of the soil, if I may use such an expression, should be attended to, so that the roots may find an easy passage in search of their food. This is effected by disc and spring tooth harrows Finally cultivation with harrow must be thorough in order to preserve an earth mulch which will prevent surface evaporation of the soil moisture.

An important factor towards productiveness or soil fertility, is tilth, and good tilth can only be obtained by following out methods based on scientific principles. The liberation of plant food in the soil, the lightening or consolidation of the soil, as the case may require, the absorption and retention of moisture, and the like, are all dependent upon a right mechanical treatment of the soil.

HUMUS IN THE SOIL.

Again there are many soils which stand in need of humus. Humus results from the decaying of vegetable matter. Where we find rich virgin soil, there we find humus. Humus has certain elements of plant food invariably associated with it, and these are in a condition easily assimilable by crops. Soils can most readily and cheaply be enriched in humus by turning under a green crop, preferably one of the legumes, such as clover. Moreover, the presence of humus keeps the soil with a due proportion of moisture. The continued cropping of a soil without growing clover tends to deplete the soil of its humus.

VALUE OF LIME IN THE SOIL.

Then the examination of these soils leads me to the opinion that many are deficient in lime. Such rapidly become sour; and a sour or acid soil is unsuited to growing crops. Where the percentage of lime falls below one per cent, most agricultural chemists deem that soil deficient in lime. Lime has its abuses as well as its uses, but I think we may well call the attention of farmers to the rational use of this constituent in some form, because its presence is necessary for the best returns. Not only is it a direct plant food, but it liberates other plant foods, notably potash, and is a valuable and important instrument in bringing about good tilth and correcting sourness. The judicious application of lime, marl or gypsum has proved most advantageous.

By Mr. Wilson:

Q. What is the nature of marl?

A. It is carbonate of lime. It is called "mild" lime, as its action is not so immediate as quick or slaked lime; but for many soils it is better, and as it is frequently found in large deposits it is certainly cheaper than quick lime.

By Mr. McGregor:

Q. Have you made any calculations as to the proper amount of lime to apply per acre?

A. It would depend upon the percentage of lime in the soil and what previous treatment the soil had had; but I presume that under ordinary circumstances, 40 bushels to the acre would be a good dressing. I would not advise a heavy dressing, as it would tend to over-stimulate and exhaust the soil, more especially if other fertilizers are not used.

By Mr. Wilson:

Q. Do you mean 40 bushels of unslaked lime?

A. Yes; it is allowed to slake by placing it on the soil in small heaps. These heaps are covered with a little earth and allowed to slake spontaneously. In a few days it can be spread easily, being then reduced to a powder.

By Mr. Semple:

Q. Would lime be as necessary where the land has a limestone bottom, or where limestone is found on top?

A. No. It is only where, as I was pointing out, the soil is deficient in lime. The soil on a limestone rock foundation may contain from 2 to 5 per cent of lime. Such a soil does not require lime. Hence, the necessity for a chemical examination of the soil, or a field test with lime, to see if there is any response. I do not recommend heavy applications, but rather small dressings at more frequent intervals. Lime has a tendency to sink into the ground, and consequently is frequently found in the subsoil in larger amounts than in the surface soil. This points to the wisdom of small and frequent dressings.

By Mr. McGregor:

Q. Would you dress on top of a crop?

A. Not necessarily; it would depend on the nature of the crop. Clover may be top-dressed with gypsum, which is sulphate of lime. This is found to give excellent result.

IMPROVEMENT OF MUCK SOILS.

We have conducted some experiments in connection with improvement of muck soils. A thorough drainage for such soils is, of course, of primary importance in order to get rid of the excess of water and correct sourness. . That is the first step. We have found that such soils while naturally rich in humus and nitrogen, are particularly deficient in some of the mineral constituents. From pot experiments conducted in our laboratories at the farm, it has been found that the crop-producing power of such soils may be greatly increased by the application of wood ashes, in other words, by potash, phosphoric acid and lime in available forms. These are the elements in which muck soils are more particularly lacking. These experiments have met with great success, and we have been able to give ocular demonstration of the fact that the yield has been very much improved by such an application. The data of these experiments will appear in the forthcoming report.

FERTILIZING DEPOSITS.

With regard to the naturally occurring fertilizers, such as mucks, mud and river and tidal deposits, marls, &c., we have as usual continued their analysis, but as I have on former occasions explained the nature of these materials, and as your time is pressing to-day, I need not now discuss their value from an agricultural standpoint. The results obtained during the past year afford useful information to those farmers to whom deposits are easy of access, for it must be remembered that many of our farmers are in a position to use such fertilizers without entailing much expense. Muck and peat in the air-dried condition are exceedingly useful absorbents for use in and about farm buildings, and I am of opinion that their more extensive use in this way would not only give our farmers a larger quantity of more valuable manure for their fields, but that much valuable plant food would be saved that would otherwise be lost. Instructions for preparations of these materials—because muck requires preparation before it can yield its constituents for plant growth—are set forth in the report.

PRESERVATION OF BARN-YARD MANURE.

In the preservation of barn-yard manure we have undertaken to estimate approximately during the past year the losses that follow upon various methods of preserving it. Some of these experiments are not yet completed, but sufficient data have already been obtained to show that in rotting manure there is a distinct and considerable loss of its fertilizing constituents, even when precautions are taken to have the conditions of fermentation as favourable as possible—that is, when excessive fermentation can be controlled and checked, and when leaching from rain can be prevented. The losses that occur when manure suffers excessive fermentation, known as fire-fanging, and when by rain it is leached, ought to be well known to the farmer. The first, known as fire-fanging, leads principally to the loss of nitrogen (the most costly element of plant food) and humus; and leaching leads not only to the loss of nitrogen, but of potash as well. We are, I dare say, all well aware of the value of nitrogen and potash as elements of plant food, but we have not hitherto recognized the importance of humus, or decaying vegetable matter, in the soil. It is found in every productive virgin soil, and experiments carried on, on the Continent and in the United States, have gone to show that it is the mineral plant food in association with humus that is most easily and readily assimilable by crops. Hence the necessity of having our soil rich in humus. Besides its chemical benefits, humus also acts most beneficially from a mechanical standpoint, it is a potent agent in the retention of moisture and in the improvement of tilth generally. The losses through excessive dry fermentation are the loss of humus and nitrogen, and through leaching, chiefly, nitrogen and potash. To compensate for the losses that occur in the rotting of the manure, because they are compensations, we have the rendering more assimilable of the plant food in the manure. In other words, rotting or fermentation makes the elements of fertility more immediately available. Whether the one may balance the other can only be decided when all the conditions and circumstances are known. For heavy soils there can be but little doubt that the greatest economy lies in applying the manure fresh and at once turning it under. Such soils are retentive of the manurial elements, and consequently suffer but little loss from drainage.

By Mr. McGregor:

Q. Would you put it on in the winter?

A. If there is not much snow on the ground. When the manure is placed upon deep snow it prevents the frost from coming out in the spring and often delays the spring work. It would not be good practice to put manure upon a sloping side where it might be leached in the spring by surface flooding. The principle is that with a retentive soil there will be less loss by getting the manure into the soil as quickly as possible. Rotting manure in the soil would improve a heavy soil mechanically.

By Mr. Rogers :

Q. Would you plough that deeply?

A. No, as the tendency of the manure is to work down, in most instances it is better economy not to bury it.

On the other hand, light and leachy soils are more economically treated by annual applications of partially rotted manure. They are not retentive, and it is well in such cases to add the manure in a readily assimilable condition, that is partially rotted so that the crops may at once utilize it. Such an application should be made from year to year.

By Mr. McMillan :

Q. Experiments have been carried on at the farm with both green and rotting manure, side by side, which is best?

A. These experiments you refer to were not under my charge, but I know that the results obtained by the Director are in favour of green manure. I am speaking now with regard to the principles of manuring.

In order to build up or work towards a permanent improvement of light soils, it would be more economical to first use the legumes. By ploughing under several green crops, the soil would be brought into a more retentive condition, and then manure could be applied with less risk of loss through leaching.

There are other matters which should be considered in arguing the question as to whether fresh or rotted manure is to be applied, as for instance, the crop to be grown. If the crop has a long growing period, as most of the root crops, we may supply it with plant food, the greater part of which is not immediately available, that is we can give it fresh manure. But where the crop is a short lived one, such as the cereals, then I am of the opinion, that the best returns would be obtained by supplying the plant food in a more or less available form such as is to be found in rotted manure.

By Mr. McMillan :

Q. Would the benefit of leaving the manure to rot in the barnyard or in a shed not be lost by allowing it to lie over all summer? Would you be recompensed for the loss resulting from not getting it out the first year, by the benefits to be derived from the rotted manure?

A. The extent of the loss will of course be dependent on the conditions of rotting the manure and the length of time in rotting. If proper precautions are taken to keep it moist and compact, the loss will not be so great as when allowed to lie over loose and uncared for. There will be loss, however, under the best conditions, and I think it becomes a question to consider whether this loss is compensated for by rendering more available the fertilizing elements. For certain crops and certain soils I believe that that loss is more than compensated for by the increased assimilability of the plant food left in the manure.

By Mr. Wilson :

Q. It is light soils in which that would be the result?

A. I think for light soils growing short lived crops more particularly, the manure should be in a partially rotted condition, that is to say, when its plant food is more readily assimilable or available than it is in fresh, green manure.

Q. That is the kind of soil that it would pay best to rot your manure for.

A. Yes, exactly.

As you are well aware, truck or market gardening and intensive farming cannot be carried on without rotted manure. The market gardener grows several crops a year on the same ground. He therefore needs manure that gives an immediate return. Where a farmer, however, has roots, for instance, growing for several months, it might be more economical to use fresh manure.

Q. But on light soil it would pay best to use rotted manure?

A. Yes.

Mr. McMillan—I know of one gentleman who for a number of years took the first prizes in potatoes, mangels, turnips and carrots in Toronto. I was very anxious to learn how he managed his soil, and I ascertained that he raised the crop always in one field. One drill being under crop and the next drill under cultivation, or in other words, each alternate drill was under crop while the intervening drills were under cultivation. The drill which was to produce the crop next summer, was manured and wrought this summer, so that the manure should be thoroughly assimilated for the next year's crop.

By Mr. Wilson :

Q. How far apart were the drills?

Mr. McMillan —The drills were five feet apart, the intervening drills being cultivated so as to assimilate the soil for the next year's crop.

By Mr. Martin :

Q. How long would green manure have to remain in the soil before becoming assimilated?

Mr. Shutt —That would depend largely on the nature of the manure and of the soil and the season. If the manure contained a considerable amount of straw (such as is often carried out to the fields by our farmers) and there was but little moisture in the soil, it might lie in the soil for several seasons without suffering decomposition; but if the manure contained a large percentage of excrement and was turned under, the soil being exposed to favourable climatic influences, the manure would for the most part be rotted the first season. The rotting of manure may proceed until there is nothing left but the mineral constituents. But for ordinary purposes, the rotting may go on for three to six months. As rotting proceeds the manure will be continually decreasing in weight, losing its organic matter and nitrogen. To a certain extent the percentage of nitrogen will increase. The percentages of potash and phosphoric acid also become greater. The extent of the losses that ensue in fermenting or rotting manure will, therefore, be dependent on the circumstances. Under ordinary conditions, that is to say, using no special precautions, we found that the shrinkage in weight was between 60 and 75 per cent. In other words, one hundred pounds of fresh manure will yield, when rotted, between 40 to 25 pounds, according to the state to which you advance in the process.

By Mr. McMillan :

Q. And according to the amount of straw in it?

A. Exactly.

The resulting manure was about twice as rich in the elements of fertility as the fresh manure. Thus we found that the percentage of phosphoric acid in the fresh manure was ·32, and in the rotted manure it was ·73. This goes to prove that under the conditions of rotting, in this investigation, the phosphoric acid had not leached out. In the fresh manure the percentage of potash was ·76, and in the rotted manure it was 1·49, showing, as I have already stated, that weight for weight, rotted manure is much more valuable than fresh manure, and this is more especially true when care has been taken to prevent fire fanging and leaching.

By Mr. Erb :

Q. How were these experiments conducted? Are those the percentages that are contained in a given weight of green manure and the same weight of rotted manure, or on the weight of rotted manure that was obtained from a similar weight of green manure?

A. The figures that I have just given you were obtained from the analysis of green and rotted manure. They are percentages, or in other words, represent the number of pounds in 100 pounds of fresh and rotted manure, respectively.

By Mr. Featherston :

Q. What is the percentage of fresh manure compared with rotted manure?

A. The analysis of a sample of fresh, mixed (horse and cow) manure, afforded us the following data :—

	Per Cent.	Pounds per ton.
Nitrogen	·52	10·4
Phosphoric acid	·32	6·2
Potash	·76	15·2

A similar sample, after the manure had been thoroughly rotted furnished the following figures :—

	Per Cent.	Pounds per ton.
Nitrogen	·888	17·76
Phosphoric acid	·733	14·66
Potash	1·496	29·92

These figures undoubtedly prove the superior quality of rotted manure. Further we have good reasons to suppose that the elements of fertility in the latter are more soluble and available than those in fresh manure. This concentration, however, is accomplished at the expense of certain organic constituents.

In the rotting of the manure nitrogen is lost and humus or organic matter is destroyed. If there is any leaching, potash, in addition to these, will be lost.

By Mr. Featherston :

Q. What is the loss then of rotting?

A. First there is a shrinkage in weight. This may vary from 40 per cent to 70 per cent. Under ordinary good conditions I presume that the decrease is somewhat more than one-half the weight of the fresh manure.

Our experiment in this matter, in which no special precautions were taken, furnished the following weights :—8,000 pounds of fresh manure became reduced to 2,659 pounds by rotting during one year. The total weights of the constituents at the beginning and end of the year have been calculated as follows :—

	Nitrogen.	Phosphoric Acid.	Potash.
	Lbs.	Lbs.	Lbs.
8,000 pounds of fresh manure, contained	41·6	24·8	60·8
2,659 pounds of rotted manure, resulting therefrom, contained	23·6	19·5	39·8
Loss of constituent in rotting	18·	5·3	21·0

This experiment is now being repeated under somewhat different conditions; conditions, at all events, that will lead to less loss of phosphoric acid and potash.

I am convinced that fermentation or the rotting of the manure in the barn-yard leads to much greater losses than is indicated above. The probability is that under conditions as usually found on farms, one-half of the plant food is lost before the manure gets into the ground.

By Mr. McMillan :

Q. The only way is to weigh the manure coming from the stables, analyse it, set it apart and analyse it from time to time, to see the loss in weight and constituents?

A. We have done that.

By Mr. Erb:

Q. And give the results in pounds instead of percentages?

A. Yes, we are giving that information. Our experiment consisted in keeping manure in an open shed and under cover. The two lots weighed and analysed every month. We not only estimated the total plant food, but also determined the percentage of it that become available by the process of rotting.

The analytical work is not yet finished, but we trust the results will be ready in about two months' time.

Q. Have you tried liquid or solid manure?

A. Our experiments have been conducted on manure made by keeping the solid and liquid manure together. Liquid manure more readily ferments and suffers loss of nitrogen than solid excrement. The advice to be given to those preserving manure is to keep it compact, in order to exclude the air as much as possible, and to keep the mass moist. Under these circumstances there will be the least loss.

PHOSPHORIC ACID IN MINERAL PHOSPHATE.

We made an experiment to ascertain if any of the phosphoric acid in ground "mineral phosphate" could be rendered soluble by mixing it with rotting farm-yard manure. You are probably aware that the phosphoric acid in mineral phosphate or apatite, is in an insoluble and therefore unavailable condition. When this material is treated with sulphuric acid, super-phosphate—in which phosphoric acid is soluble—is formed. It has been repeatedly urged that if the finely ground mineral phosphate was composted with actively fermenting manure, the same result would follow, namely, the rendering soluble of the phosphoric acid.

We took 50 pounds of apatite per ton of manure, allowing the mass to ferment from April to August. Further analyses were then made. They showed that no phosphoric acid had been thereby rendered soluble. We, therefore, have very good proof for saying that the fermenting manure has no influence on this apatite.

CLOVERS AS GREEN MANURES.

In the question of enriching soils by turning under clover—one that has been attracting a great deal of attention of late—we have done some further work during the past year. In my report for 1895 I discussed at some length the benefits to be derived from this method of fertilizing, giving analytical and full data of our experiments. We have followed up the work during 1896, and estimated the approximate gain per acre by ploughing under Alfalfa, Mammoth Red Clover, Crimson Clover and Common Red Clover. This investigation was undertaken to find out which of these crops yielded the largest amount of nitrogen and humus, that is to say, which was the most valuable for turning under. The results showed that Alfalfa or Lucerne stood first in point of nitrogen, humus and mineral matter; it was closely followed in many particulars by the Mammoth Red Clover. There are many advantages to be got by using Alfalfa. It has the most extensive root system of all the clovers tried, and more than half the nitrogen is found in the roots. The value of such a crop as a soil enricher is therefore obvious, even when the foliage -stems and leaves—are used for soiling purposes. It is not so with Crimson Clover, for instance, where less than half of the whole nitrogen is contained in the roots.

The following table shows the composition, the weight of crop per acre, and the amounts of the more important constituents per acre :—

Clover.	Composition.			Nitrogen.	Weight of Crop Per Acre.		Amount of certain Constituents Per Acre.		
	Water	Organic Matter.	Ash.				Organic Matter.	Ash.	Nitrogen.
(Sown July 13th, 1896, Cut October 20th, 1896).					Tons.	Lbs.	Lbs.	Lbs.	Lbs.
Crimson Clover, stems and leaves..	83·32	13·91	2·77	0·382	11	234	2,093	602	85
" roots	83·87	12·92	3·21	0·304	3	201	801	199	19
Total	......	... .	....	....	14	435	2,894	801	104
Alfalfa, stems and leaves.........	71·63	23·81	4·56	0·671	5	1,192	2,664	510	75
" roots	64·74	29·47	5·79	0·557	5	558	3,120	613	61
Total	.....	.. ...	.....	....	10	1,750	5,784	1,123	136
Mammoth Red, stems and leaves..	79·13	17·05	3·82	0·620	6	1,310	2,269	508	82
" roots	77·57	19·41	3·02	0·662	3	1,260	1,409	219	48
Total	... .	....	......	....	10	570	3,678	727	130
Common Red, stems and leaves...	76·24	18·84	4·92	0·718	4	1,779	1,842	481	70
" roots	71·22	25·61	3·17	0·784	2	1,445	1,394	172	47
Total	....	....	......	....	7	3,224	3,236	653	117

The weight of crop was calculated from the yield of one square yard—the roots being taken to a depth of two feet.

The following paragraphs, taken from my current report, state in brief, the more important deductions from this investigation.

Alfalfa—In total yield of crop Alfalfa stands second. It was from this plant we obtained the largest amount of humus in the stems and leaves, as well as in the roots. It also afforded the most nitrogen per acre, nearly half of which is in the roots—a feature in which it stands alone among the clovers experimented with, and one of great importance when the crop is intended for soiling or curing. The extensive or rather deep root system is of much value in this mechanical improvement of the soil and serves to bring to the surface layers much plant food ordinarily out of reach of farm crops.

The mineral matter exceeds by 300 pounds per acre the amount in the Crimson Clover crop—the next best in this respect. More than half of the 1,100 pounds of ash constituents recorded as stored in the yield upon an acre, is contained in the roots.

Taking into consideration all the important requirements, from a chemical standpoint, of a crop for green manuring, the Alfalfa gave the best results in the present investigation.

Mammoth Red Clover.—In yield per acre, humus (organic matter) and nitrogen this crop stands a close second to Alfalfa. The amount of nitrogen in the foliage is slightly greater than that in the foliage of Alfalfa, but the roots of the Mammoth Clover contain per acre only two-thirds of the amount in the Alfalfa roots in the same area. Although the ash constituents in the foliage of these two crops are almost identical in amount, the roots of the Mammoth Clover possess but one-third, approximately, of that in the Alfalfa roots.

Common Red Clover.—Though giving the least weight of crop, this clover ranks higher than Crimson Clover in its nitrogen and humus content per acre. In ash con-

stituent or mineral matter it possesses about two-thirds the amount in Crimson Clover. Its root system is not so heavy as that of the other clovers of the experiment, but the quantity of plant food contained in it is not far behind that in the Mammoth Red Clover roots.

Crimson Clover.—In total weight of green stuff per acre, the Crimson Clover gives the highest figures, but, on account of the very large percentage of water, it is seen to furnish less organic matter or humus, than any of the other crops experimented with.

As in humus, so in nitrogen, yielding but 104 pounds per acre, while the other crops give considerably higher results. In this connection it is worthy of note that the Crimson Clover roots are very poor in nitrogen, and therefore when this crop is intended as a nitrogenous enricher, the whole plant should be turned under.

The amount of mineral matter assimilated stands second in the tabulated results. This clover, when turned under, furnishes a large amount of ready prepared mineral food for succeeding crops, but the root system is not as rich as any of the others examined.

During the last two or three years we have been sowing clover with the cereals, and have found that it has not decreased the yield of grain. This is a practice that could be more generally followed with advantage. I could not recommend any better or more economical plan for keeping up a soil's fertility in nitrogen and humus, than in occasionally ploughing under a green crop of one of the clovers.

WOOD ASHES.

In the matter of fertilizers we have made an examination as to the respective values of maple and basswood ashes. We found that maple ashes contained approximately twice as much potash as basswood; but that the basswood ashes are much richer in phosphoric acid. The figures are :—

—	Potash.	Phosphoric acid.
Maple ashes	6·5	1·6
Basswood ashes	3·7	2·8

Potash is an important element of fertility and where unleached hardwood ashes can be purchased for from 10 to 15 cents per bushel they certainly afford the cheapest source of potash for agricultural purposes. I am further of opinion that with a rational system of farming including green manuring with legumes and the use of hardwood ashes, our ordinary farmers would be independent of the purchase of commercial fertilizers. Wood ashes not only supply potash but furnish phosphoric acid, lime and other mineral plant food constituents. Hence when they can be obtained the purchase of superphosphate, lime, gypsum, etc., is very seldom necessary. When wood ashes cannot be procured, kainit, muriate of potash or other of the German salts must be used to supply potash, and superphosphate used to furnish phosphoric acid.

GARBAGE ASHES FROM CITY REFUSE.

Many inquiries have been received from farmers living in the vicinity of large cities as to fertilizing value of the ashes from crematories. We, accordingly, made several analyses and found as a result that these ashes were extremely variable. As a rule they are inferior to wood ashes. A sample from Toronto refuse contained 2·2 per cent of phosphoric acid and 2·82 per cent of potash. These results show it to be decidedly inferior to good wood ashes, as regards potash. I might say that two samples, sent or

different dates from Vancouver, were found to contain a large quantity of phosphoric acid, evidently derived from the presence of a large quantity of bones in the refuse. They showed from 11 to 13 per cent of phosphoric acid. The first sample contained 1·74 per cent of potash and 11·66 per cent of phosphoric acid. The second sample contained 2·15 per cent of potash and 13·05 per cent of phosphoric acid. All this serves to emphasize that th·se materials are very variable in composition, and that before purchasing an analysis should be demanded.

COMPOSITION OF WHEAT BRAN ASH.

We have ascertained the composition of wheat bran ash. It appears that wheat bran is sometimes used in the Manitoba flour mills as fuel. When the price falls below $4 per ton it is contended that bran is the cheapest fuel they can use. We have found that a ton would contain phosphoric acid and potash to the value of $78, valuing these constituents at the same price that they cost in commercial fertilizers. The ash contained 25 per cent potash and 45 per cent phosphoric acid, or 500 pounds of the former and 900 pounds of the latter per ton. However, burning the bran is a wasteful practice. To obtain a ton of ashes (valued at $78), $100 worth of nitrogen is burnt away or wasted, so that the best and most economical treatment of the bran which cannot be fed would be to compost it. Bran is rich in nitrogen, which is all lost in the burning.

By Mr. McGregor:

Q. How about feeding it?

A. Undoubtedly that would be the most economical plan, for by so doing you would obtain two profits instead of one. By composting it all the nitrogen would be saved that is lost by burning, practically amounting to $100 worth for every $78 worth of potash and phosphoric acid. We also determined the relative values of oil cake, germ meals, and other grain feeds.

By Mr. McMillan:

Q. In calculating with respect to clover, grown for ploughing down, would it not be better to feed it to animals and then apply it in the form of manure?

A. Undoubtedly; where it can be fed to cattle, and the manure taken care of, feeding is the best method, because you get two profits instead of one; but where there is no stock, and the only question is to improve the soil, you can obtain nitrogen and humus cheaper by clover than by purchasing commercial fertilizers—and that is the point that I wished to make in speaking of the clovers as green manures.

ANALYSES OF WELL WATERS FROM FARM HOMESTEADS.

We have also continued the work of examination of wells on farmers' homesteads. Last year we examined in the neighbourhood of fifty samples of water, and of these we found forty-five per cent so seriously polluted that I was compelled to condemn them as unsafe for drinking purposes. Twenty per cent were returned as suspicious and in all probability unsafe for use, and thirty-five per cent were returned as unpolluted and wholesome.

The other work of the chemical division has been of an exceedingly varied character. Addresses have been delivered at agricultural meetings and conventions on subjects relating to soils, fertilizers, cattle feeds, &c. Correspondence, which is continually on the increase, forms a most important branch of the work. Farmers may apply to us for information on any subject, without even the cost of postage, and I may say that they have not been slow to avail themselves of the privilege. Nearly one-half of my time is now consumed in this matter of correspondence.

There are various experiments and investigations which we propose taking up during the coming year, and which I believe will give results of great value to the agricultural public of Canada, and I regret that we have not time this morning to discuss them, at least in outline.

Q. I think it would be very important if you could take up all the different classes of feed and analyse them carefully and give us their value.

A. Yes. We have accumulated this year further data on that subject, and as opportunity presents itself we purpose continuing the work. We should have on record data concerning the feeding value of all Canadian cattle foods.

Mr. McMillan.—That is very important.

Mr. Shutt.—You will undoubtedly be interested then to hear that we analysed last year two samples of oil-cake meal, one of which on calculation was shown to be worth four dollars a ton more than the other. It so happened that the poorer sample was being sold at a higher price. This illustrates the value of chemical analyses for ascertaining the feeding value of fodders, milling products, &c. Our work this year has been hindered no little by the fire that so seriously damaged our laboratories last July. That fire also destroyed many unpublished data, more especially those obtained by the analyses of Canadian grasses. We trust before another year to be established in a new and separate building, especially built for the chemical division. We shall then be in a position to increase the expert staff and do still more work of interest and value to the agricultural population of Canada.

Having examined the above report of my evidence I find it correct.

FRANK T. SHUTT,
Chief Chemist of the Dominion Experimental Farms.

With Mr. SHUTT'S compliments

EVIDENCE OF MR. FRANK T. SHUTT, M.A.

CHEMIST OF THE DOMINION EXPERIMENTAL FARMS

BEFORE THE

SELECT STANDING COMMITTEE OF THE HOUSE OF COMMONS

ON

AGRICULTURE AND COLONIZATION

MAY, 1898

PRINTED BY ORDER OF PARLIAMENT

WITH MR. SHUTT'S COMPLIMENTS

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COMMITTEE ROOM No. 46,
HOUSE OF COMMONS,
FRIDAY, 20th May, 1898.

The Select Standing Committee on Agriculture and Colonization met this day at 11 o'clock a.m.; Mr. Bain, Chairman, presiding.

The CHAIRMAN:—We have with us this morning the Chemist of the Experimental Farm, Mr. Shutt, whom I now introduce to the Committee.

Mr. FRANK T. SHUTT, M.A., Chief Chemist Dominion Experimental Farms, addressed the Committee as follows:—

CHEMISTRY AS AN AID TO AGRICULTURE.

Mr. Chairman and Gentlemen,—It may not be necessary for me to-day, perhaps, to bring before you any detailed account of the character of the work undertaken by the chemical division of the Experimental Farms. On previous occasions when I have had the honour of appearing before this Committee I have laid before you statements regarding the varied character of that work and the means we take to assist by chemical aid the farmers of Canada. It may, however, be well for me to point out, in fact we have the very strongest evidences of it, that our work is being appreciated by the farmers, dairymen, and the fruit growers of Canada. The evidences I refer to may be enumerated as follows: First, increased correspondence from farmers and others interested in agriculture, which generally contain questions as to the nature and composition of soils, fertilizers, cattle foods, and upon other agricultural matters; secondly, the larger number of samples submitted by farmers for examination in our laboratory; thirdly, the greater demand for our reports and bulletins and the more frequent quoting of these in the public press. These are evidences that our work is being appreciated by the people and that it has awakened a wide and lively interest in the value of chemical knowledge in the every-day work of those engaged in agriculture.

In the matter of the examination of samples it is well for me to say that we have at present a very large number awaiting our attention. The time at my disposal has not permitted us to keep up with the work of analysing all these samples, which consist of soils, marls, mucks, feeding stuffs of all kinds, sent in for a report on their value. We have put these second to original investigation and postponed their examination until time permits. With an increase in the staff ,which I hope to see in the near future, we shall be able to attend to more of this work.

LECTURES.

There are two matters in connection with the general work of my department of which I wish to make mention. First, in relation to lectures delivered in various parts of the country at the larger agricultural conventions or Farmers' Institute meetings. These I am led to believe are of great importance, because by this means we are able to bring before the people who are interested and whom we cannot otherwise directly and personally reach, the principles of agri-

culture and the results of our experiments. These lectures advertise, if I may use the term, the character of the investigations being carried on by the Experimental Farms. Another benefit to be derived from these lectures by the farm staff and the discussions that follow, is that it allows us to arrive at a better knowledge of the needs of the farmers and the problems confronting them which need immediate solution. By reason of the discussion which follows the addresses at those meetings we are enabled to learn, in a way that we cannot otherwise do, the wants of the farmers. These meetings also give us the opportunity of learning the conditions both of climate and soil that prevail in various parts of the Dominion, and this information is of immense value to us in our work. These lectures on the first principles of agriculture and on the results of our experiments are of great usefulness, and I think the system of lecturing might with advantage be extended so soon as time and money permit.

The second matter was the delivery of a special course of lectures to the Normal School students at Ottawa by various members of the Farm staff. As you are aware these students are to become the future teachers in the rural districts and I consider this a very wise departure, because by this means we disseminate the work of the farm and a knowledge of agriculture throughout the province of Ontario. I think we may expect very good fruit from these lectures in future years.

It is my purpose to-day, with your permission, and if time permit, to bring before you some of the results obtained during the last year on certain lines of investigation. First, I shall lay before you the results of some elaborate—or rather extensive—investigations in the matter of the preservation of barn-yard manure; and secondly, I shall speak of some results we have obtained in the use of a new compound prepared in Germany known as nitragin ,of which I shall refer to at some length later on, and which is used for the purpose of encouraging the growth of such plants as clover, beans, and other legumes; and thirdly, I purpose speaking on the water supply of farms.

PRESERVATION OF MANURE.

These experiments in the matter of the preservation of manure were commenced in April, 1896. They constitute a series of experiments which are, I believe, the first of their kind in Canada. As this work is only just finished, we have to-day the first opportunity for presenting the result of these experiments to the public. They are, of course, only the beginning of further investigations of a like nature which we hope to carry on; nevertheless they give us some very important and valuable information on this question, which is one that really lies at the foundation of good farming.

Probably the questions which are most frequently asked of us on agricultural platforms are: first, "Would you apply manure fresh or rotted?" And then, "If rotted, what is the best way to rot manure?" Some two years ago when speaking on this matter to this Committee, I pointed out that it was absolutely impossible to reply to the first of these questions in a single sentence unless indeed you were to say: "It all depends." That is to say, that all the circumstances and conditions of soil and climate and the character or nature of the crop to be raised have to be considered before we can advise as to whether it might be advisable to apply manure fresh or rotted; nevertheless there are certain principles which we can master and which help us to apply an intelligent judgment in coming to a decision. The questions which have to be considered in answering such a query are, first, the character of the soil—heavy clay soils and light sandy soils requiring different treatment. We know that barn-yard manure has two beneficial functions, one of which is mechanical and the other chemical. A heavy clay soil we seek

to loosen or render more porous, while we wish to bind with light sandy soil and render it more compact; consequently, considering the question from the mechancal standpoint, we should apply fresh manure to the heavy clay soil, while to the lighter soils we should apply rotted or partially rotted manure. Looking at it from the chemical standpoint I again say that fresh manure should be applied to the heavier soil, because clay soils are more retentive and consequently may be used as a storehouse; but on the light soils I prefer to feed the crop rather than manure the soil, because such light soils are leachy and cannot be viewed as good storehouses in the same way that the heavy clay soils are. Then the nature of the crop has to be taken into consideration. If we have a short-lived crop it is necessary to feed it with food more or less immediately assimilable—and it is in such a form that we find it in rotted manure. Such crops as cereals and the ordinary grain crops are short-lived crops, but when we have a crop which grows throughout the whole length of the season, as, for instance, root crops, we may feed them with food which is not entirely of an immediately available character, and do so with advantage. The question of the foraging power of plants for food is also one that has to be studied. We know something about that, but not very much. Some plants can acquire food from a soil in which other plants would starve.

Having given these outlines in regard to the principles—I have merely stated them in outline—of the application of manure, I wish to say that intimately connected with these questions is the one that takes into consideration the amount of the fertilizing elements or constituents which may be lost during the process of fermentation or rotting of manuring. This is a matter regarding upon which we wished to obtain accurate knowledge upon before replying to the question as to whether it is economical or not to rot manure.

The object of this investigation, then, was to trace the fertilizing constituents during rotting, to ascertain what loss, if any, takes place under different systems of fermentation, and also to learn the degree of availability of these constituents at different periods of fermentation. We expected to find that during the rotting of the manure certain of these elements or fertilizing constituents would be rendered more available than they are in fresh manure, and if more available, consequently more valuable. The question of availability of plant food is an important one. For instance, the phosphoric acid in our ordinary mineral phosphate is worth about two cents a pound, commercially; it is worth absolutely nothing agriculturally, because it is insoluble and not available as food for plants. But once that mineral phosphate has been converted into super-phosphate, once that phosphoric acid has been converted into a water-soluble form it receives a value of 6 or 7 cents a pound, because it can then be utilized as a source of phosphoric acid for our crops. Applying that same argument to the question of manure, we wished to learn if through the rotting or fermenting of the manure any of its constituents were converted into more valuable, because mor ereadily assimilable, forms of plant food.

In April, 1896, we took fresh horse and cow manure and mixed them in equal proportions—and I may here say that all the experiments we carried on in regard to the preservation of manure were made with manure composed of the mixed excrement, solid and liquid, of the horse and cow together with the litter that has been used for the bedding of these animals—and that constituted the manure experimented upon.

By Mr. Stenson :

Q. Is that in equal parts in weight?

A. Yes, equal parts by weight. Four tons of this mixed manure were placed in a small wooden building which was practically weather-proof, and a like

weight of four tons was exposed in an open bin constructed with double flooring and sides. Ordinarily, we should have said that this bin was one in which manure could be preserved without loss from leaching. I made photographs of this shed and of the open bin in which these experiments were conducted, and they give a very good idea of the conditions under which the experiment was carried on. You may see here (exhibiting photograph) the shed in which the protected manure was preserved and also the open bin adjoining it, in which the exposed or "outside" manure was kept. These manures were weighed, sampled and analysed, month by month, for one year, so that we have a record of the composition and the total weight of these manures month by month for that period. Consequently from these data we are able to trace up the various constituents as the process of fermentation proceeded. The analysis comprised in the determinations of the moisture or water that is contained in the manure—ordinary fresh manure contains about 70 per cent of water—the organic or vegetable matter and the mineral matter or ash. These three constitute the whole. We also determined the total nitrogen, and nitrogen present as ammonia and as nitrates and nitrites, and the percentages of potash and phosphoric acid, total and available.

By far the larger amount of nitrogen is contained in the organic matter, and is therefore known as organic nitrogen. Nitrogen also is present in small quantities as nitrates and nitrites and as ammonia. These latter are the results of fermentation; in fresh manure there is no ammonia present and no nitrates. It has been found that our farm crops take up their nitrogen in the form of nitrates, hence the importance in learning the effect of fermentation upon their formation. The nitrogen of the organic matter is converted by the aid of microbes, bacteria or germs, into ammonia, nitrates and nitrites, and it is important, from an agricultural standpoint, to trace the conversion of the nitrogen into these immediately assimilable forms.

We determined the phosphoric acid and potash dissolved out of the manure by strong hydrochloric acid. Such would represent all the phosphoric acid and potash present in the manure; we also determined the phosphoric acid and potash that was soluble in dilute citric acid. The reason for this latter determination is that it has been found that the solvent action of dilute citric acid (1 per cent solution) is practically equivalent to the solvent action of the exudation of plant rootlets. Any fertilizing material in the soil soluble in one per cent solution of citric acid, is present in a form that is of immediate value to our crops.

These manures, both "inside" and "outside," were practically the same as to composition and condition at the beginning. The mixing was carefully and thoroughly done, and samples, as representative as could be obtained, were taken and submitted to analysis. The composition as revealed by the initial analysis was as follows:—

			Per cent.
Water	68·[illegible]	Total nitrogen	·601
Organic matter	24·[illegible]	Immediately available nitrogen	·083
Ash	7·16	Total phosphoric acid	·31
		Immediately available phosphoric acid.	·19
	100·00	Total potash	·76
		Immediately available potash	·68

The total nitrogen was ·601 per cent and nitrogen as ammonia ·083 per cent.

I would draw your attention to the very small amount of nitrogen which exists in fresh manure in the form of ammonia. The total phosphoric acid was ·31 per cent, and the available phosphoric acid was ·19 per cent. The total potash was ·76 per cent, and the available potash ·68 per cent. To convert these into pounds per ton, we have nitrogen amounting to 12 pounds per ton; the nitrogen existing as ammonia and nitrates 1·6 pounds (practically 1½ pounds); phosphoric acid, total

6·2 pounds per ton, that part of it immediately available amounted to 3·8 pounds per ton. Respecting the potash, the amount would be 15·2 pounds per ton, and that immediately available 13·6. As I have already observed, in fresh manure a very small proportion of the nitrogen is immediately assimilable; of the phosphoric acid practically one-half is immediately assimilable, and in the case of potash a very large proportion, between 90 and 95 per cent is immediately assimilable. Consequently we cannot say that the process of fermentation increases the value of the potash. I have termed this *fresh* manure with which we begain to work, but you must understand that it took about ten days to collect the desired quantity, namely, 8 tons, and as a result it had already begun to heat somewhat.

By Mr. Bell :

Q. What season of the year was it ?

A. April, and despite all precautions we could take, fermentation had begun when the samples were taken. The reason I dwell on this point is that we find by these experiments that it is in the earliest stages of fermentation that the greatest change in the composition of manure takes place, and probably such loss as did ensue resulted more particularly during the earlier stages of fermentation. We shall get data on that as we proceed. Now, having spoken of the composition of that manure that we used in these investigations, it is right for me to draw your attention to the fact that this manure is of greater richness than that which we ordinarily find in farm-yards in Canada. We have analysed a considerable number of samples of barn-yard manure obtained from various sources and we have not found them to be as rich in plant food as this manure made on the Central Farm. I will compare our average Experimental Farm manure with the figures which may represent the average on good, fairly well-kept farms. Of course, we understand that the composition of manure is variable. I am obliged, therefore, to take averages from numerous samples. I find the results as follows:—

	Exp. Farm.	Average obtained from other samples.
Nitrogen, per ton..................	12·0 lbs.	8·0 lbs.
Phosphoric acid, per ton...........	6·02 "	3·08 "
Potash, per ton....................	15·2 "	9·0 "

It will be seen that there is in the ordinary manure only about two-thirds of the nitrogen contained in that of the Central Farm, about one-half the phosphoric acid and about two-thirds the potash. There are many ways in which we can account for these differences. I am of opinion after considering the question very closely, that there are several factors which may account for these differences. First of all there is the kind of food fed to the animals. We are aware that as the richness of the food so is the richness of the resulting manure. Foods rich in nitrogen give manure rich in nitrogen. Similarly, foods rich in potash give manure rich in potash. It follows that the manure from cattle living on the straw stack will contain low values. Animals cannot create anything. They use their food to supply their various needs—for development of vital heat and energy, for the repair of waste tissue—to produce flesh, milk and wool. Consequently if the food does not contains the necessary constituents in large proportions, the animal having provided for its maintenance, the resulting manure will be poorer than that produced when the animal is fed stronger, richer food. Then the animal's age has something to do with the richness of the manure. Young animals take more from their food in order to build up their flesh and bone than mature animals, and therefore their

manure is poorer than that from mature cattle. Dairy cattle necessarily take more from their food than fat stock and consequently do not furnish as rich manure as fattening steers. Apart from that, there are other questions to be considered. In ordinary farm-yard manure probably there is not so large a proportion of horse manure.

By Mr. Bell (Addington):

Q. In connection with the value of manures, comparing those of the Experimental Farm with those of the ordinary farmer, does not the loss of the liquid materially affect the value?

A. Very much so. I was just going to deal with that question and was about to say that I considered this was a question of very great importance. I attribute the very great difference which I have pointed out here, very largely on the one hand, to the insufficient use of litter to absorb the liquid manure, and on the other hand to faulty methods in the manure's preservation. I think we ought to take every opportunity to point out to our people that greater care is necessary to retain the liquid portion of the manure. We know that the potash of manure is practically all contained in the liquid portion. Over 90 per cent of the potash is present in the urine. When this is lost the resulting manure must necessarily be poor in potash, which is an important constituent for all crops, especially for leafy crops. At the Central Farm we have a liquid tight gutter behind the animals, both horses and cows, and we use plenty of litter, we therefore minimize the loss of the liquid portion of the manure. The large percentage of potash in the Experimental Farm manure is due, I believe, to the fact that there has been greater care in the preservation of the urine.

By the Chairman :

Q. You think it is in the liquid part that the potash is ?

A. Yes, and in addition to that all the available nitrogen is present in the urine. It readily ferments giving rise to ammonia which may then be further converted into nitrates. These compounds, as we have already stated, are of the greatest value as plant food.

PROTECTED MANURE.

Now, I shall speak first in regard to the manure which was protected or preserved in the weather-tight shed. We began the experiment with 8,000 pounds. At the end of one month the weight of the protected or inside manure was reduced to 5,006 pounds. The total nitrogen in the 8,000 pounds of fresh manure amounted to 48 pounds, in round numbers. At the end of one month there were 42 pounds, showing a loss of 6 pounds, which is equivalent to a loss of 13 per cent of the amount of nitrogen originally present. There was no loss in potash or phosphoric acid. There was, however, a very marked increase in the percentage of assimilable phosphoric acid, that is to say, phosphoric acid soluble in this one per cent of citric acid solution. In the fresh manure we found approximately 25 pounds of phosphoric acid, and of that 15 pounds were immediately assimilable. At the end of one month analysis showed that there was no loss of phosphoric acid; there were still 25 pounds, but instead of 15 pounds being available there were 22 pounds of it available, so that the fermentation during the first month had acted beneficially in the conversion of this phosphoric acid from an insoluble form into a form which was available for plants. This corresponds to an increase of 24 per cent in the availability of the phosphoric acid originally present. We found that in the 8,000

pounds of fresh manure at the beginning of the experiment there were 61 pounds of potash, of which between 54 and 55 pounds were immediately assimilable. At the end of one month analysis showed that there has been no loss of potash; indeed, slightly higher numbers were obtained. It does not appear that fermentation had any marked effect upon the solubility of the potash in the manure. These facts, which are now first brought to light, are of great importance because they point out that as regards the potash in the manure we cannot hope for any beneficial action from fermentation, but we may rather expect, especially in faulty methods of preservation, a loss, because potash is an exceedingly soluble constituent and apt to leach away. A remarkable feature in this connection, and one worthy of note, is the very large proportion of potash in fresh manure which is soluble and available. There were practically 55 pounds out of 60 pounds immediately assimilable.

THE FUNCTIONS AND VALUE OF HUMUS.

The loss in organic matter during the first month amounted to 500 pounds. That is an important matter. There were in he neighbourhood of 1,940 pounds to begin with, and at the end of one month there were 1,440 pounds of organic matter. I am not speaking of the decrease in total weight, but of the decrease in the amount of organic or vegetable matter contained in the manure. Organic matter in barn-yard manure undoubtedly has several most valuable functions. It is by the rotting of this organic matter that humus is formed, a term applied to the semi-decayed, partially decomposed vegetable matter and is that which constitutes the black material in fertile and all productive soils. We find that fertile virgin soils almost invariably contain a large percentage of humus. We can consider this question of humus from two points of view, the chemical and the mechanical. In the chemical we find that it is a storehouse of nitrogen. It is the natural guardian of nitrogen. Soils rich in humus are rich in nitrogen; those poor in humus are as a rule poor in nitrogen. Then, again, it has recently been discovered from experiments carried on abroad, that it is from the phosphoric acid and potash of the soil combined with the humus that the plant rootlets absorb these mineral constituents. The decomposition of humus acts beneficially in liberating soil plant food. But there are equally important mechanical functions of humus. It holds and retains moisture; it also opens up heavy soils and binds the lighter or sandy soils. Consequently, we can see that the presence of humus is of great importance and it is generally to the advantage of the farmer to increase the percentage of humus in his soil. Further, this humus or semi-decomposed organic matter is the material which furnishes food for the germs in the soil, which germs or microbes do a vast amount of exceedingly valuable work in preparing food for crops. It is therefore a most valuable constituent for all classes of soils. It is the storehouse of nitrogen. It furnishes food for bacterial life in the soil, so necessary for the conversion of plant food from its locked-up stores into assimilable forms. It regulates the moisture and heat of the soil and it is from their combination with humus that phosphoric acid and potash are taken up by plants. We see, therefore, the great value of humus in soils. We should guard against excessive loss of organic matter from fermentation, for I am convinced that a considerable part of the benefit derived from manure is due to the humus it supplies.

The samples of the manures taken for analysis at the end of the second month were, unfortunately, lost in the fire that nearly destroyed the laboratory. We cannot, therefore, give analytical data of the manures at the end of the second month. But we can discuss their nature at the end of the third month. The total weight of

the protected manure had, by this time, been reduced to 2,980 pounds, the organic matter to 879 pounds.. In other words, the rotting for three months under cover had reduced the total weight 63 per cent. During the first month rotting under cover had resulted in a loss of 26 per cent of organic matter. By the end of three months the loss amounted to 55 per cent of organic matter. That is to say, the rotting of the manure for three months resulted in a loss of something over one-half of the organic matter. This rotting or fermentation is brought about by the agency of germs or microbes, and it was due to their development, since they feed upon organic matter, that this loss occurs.

The original amount of nitrogen was 48 pounds ; in the course of three months fermentation had reduced it to 39½ pounds, showing a loss equal to about 18 per cent of the total nitrogen. Practically we might say that the rotting, under these circumstances (protected from the weather) had resulted, during three months, in a loss of from 15 to 20 per cent of the nitrogen.

With the mineral constituents the case was different. The phosphoric acid and the potash practically remained stationary from the close of the first month. That is, there was no further percentage of phosphoric acid rendered available and the "totals" remained unchanged. Passing on now to the end of six months, we find the total weight had been reduced to 2,308 pounds, a further reduction of about 10 per cent during that second period of three months. The organic matter was reduced to 803 pounds, this indicates a total loss of 59 per cent of the original organic matter since the beginning of the experiment.

At the end of nine months the total weight had become 2,224 pounds, showing a further reduction during the third period of 3 per cent only. The organic matter weighed now 760 pounds, representing a loss of 61 per cent of the organic matter originally present, or a loss of 2 per cent during the third period of three months. The nitrogen now amounted to 36½ pounds, indicating a total loss of 24 per cent during the nine months that fermentation had taken place. It also indicates that a further loss of 6 per cent of nitrogen had occurred during these last three months.

By Mr. Stenson :

Q. You say that at the end of three months there was a loss in the protected manure of 55 per cent of organic matter and a loss of 20 per cent of nitrogen. Now, what would be the loss, taking it altogether, of the value of that manure ?

A. We can ascribe to these elements the price that we must pay if we have to purchase them in the form of commercial fertilizers, 10 to 14 cents per pound for nitrogen. From these data we can calculate the value of the loss in dollars and cents which has disappeared through the fermentation. Though the organic matter, as I have shown, is valuable, we cannot ascribe to it any market price. In regard to phosphoric acid and potash this method does not lead to any loss whatever. During the first months of fermentation there is a conversion of part of the phosphoric acid from the soluble to the insoluble form, but we do not observe any loss in these elements.

Q. No loss in these, but there is so much loss in organic matter. At the end of three months you reduce the weight of the organic matter by 55 per cent. That would be 50 per cent of the whole weight, would it not?

A. Yes, somewhat more, but I cannot ascribe any commercial value to humus. It is not a marketable or purchaseable commodity though of great agricultural value, but in regard to nitrogen we can easily estimate the value of the loss in dollars and cents.

Q. If you have lost 50 per cent of the weight of this protected manure, has it lost 50 per cent of its value?

A. No, we have all the phosphoric acid and potash practically present in the original manure. Then, again, we did not lose 50 per cent of the nitrogen. This was reduced from 48 to 38 pounds in round numbers. At the end of 12 months there was only 25 per cent of the original weight of manure, but nevertheless that 25 per cent contained all the phosphoric acid and potash originally there and it contained 37½ pounds of nitrogen out of 48 pounds originally present, so that we lost during the whole year practically 10½ pounds of nitrogen by the process of fermenting. Ten and a half pounds, if you like to value it at 10 cents a pound, would amount, say, to a dollar. Against that you would have to put the greater availability of the phosphoric acid, the conversion of the vegetable matter into humus, and the smaller quantity which you would have to cart out to the field necessitating less labour and expense of handling. These would have to be regarded as offsets against the loss of nitrogen which has been dissipated in the process of fermenting. At the end of 12 months the total weight was 2,185 pounds, a further reduction during the fourth three months of less than one-half per cent on the original weight. The weights of organic matter, nitrogen, phosphoric acid and potash were all very similar to those at the end of nine monhs.

I will just summarize in a few words the more important facts brought out by this experiment. You will bear in mind that I am giving you merely the outline of a large amount of data we have on this subject.

First: That fermentation during the first two months serves to render available a comparatively large amount of the phosphoric acid. It increases the percentage of immediately available phosphoric acid about 20 per cent.

Second: That 90 per cent of the potash in fresh manure appears to be available and that subsequent fermentation does not seem to increase to any extent the amount or proportion so available. In respect to this constituent there is nothing gained by rotting manure.

Third: That by this means of preservation (under cover) there is practically no loss of phosphoric acid or potash.

Fourth: There is a large loss of organic matter, more especially during the first months of rotting, 1,938 pounds of organic matter becoming reduced to 1,446 pounds in one month, to 879 in three months, to 800 in six months, and to 760 in nine months.

Fifth: The loss of nitrogen amounts to 13 per cent of the total during the first month, to 16 per cent during the first three months, and there was very little loss in nitrogen after this date.

Sixth: The maximum benefit from rotting manure can be obtained in two or three months.

By Mr. Richardson:

Q. How did you obtain your samples for weighing? Did you weigh the whole thing?

A. We weighed the whole mass.

Q. Did you turn it when you weighed it?

A. Yes.

Q. That would make a great difference?

A. We turned it 12 times during the whole investigation—once at each weighing and sampling.

Q. That alters the value of the test altogether?

A. We have another test, the results of which I shall give you, in which the whole mass was left unturned. The object of this investigation was to trace up, month by month, these constituents and also to ascertain the condition in which they existed.

Q. Yes, but the difference between manure turned twelve times in the year and manure left lying in a covered shed for twelve months would be very great?

A. It would be, certainly.

Respecting nitrogen our results showed that during the first month we lost 13 per cent of the nitrogen present, and this percentage of loss was increased to 16 per cent during the first three months and that there was very little loss of nitrogen after this date. We cannot say from looking at all this that there is any benefit to be derived from fermenting manure more than two or three months. The changes that took place, took place during that period and there is no object to be attained, at least I cannot gather from our data, that there is any object to be attained in fermenting manure for a longer period.

"EXPOSED" OR "OUTSIDE" MANURE.

Now, I wish to bring briefly before you data of an analagous character respecting the manure exposed in an outside open box or bin, the flooring and sides of which were practically water-tight. At the end of one month this exposed manure had been reduced from 8,000 pounds to 5,113 pounds. The organic matter was reduced from 1,938 pounds to 1,093 pounds. The loss of organic matter in the covered manure you will remember amounted practically to 500 pounds during the first month or 26 per cent of the original amount contained. The loss of organic matter in this exposed sample was 845 pounds, equivalent to 45 per cent of the original amount during the same period. This is an important matter.

By the Chairman:

Q. The shrinkage was more rapid?

A. There was a greater loss, both of organic matter and nitrogen. The total weight at the end of one month was greater in the case of the exposed manure than in the protected manure, but the shrinkage in value, the loss of organic matter was almost double, or as 26 is to 44. The greater weight is easily accounted for, from the fact that the exposed manure was subject to every rain that fell. We found the weights of the exposed manure at some weighings to be less than those the month before, and again in some months a great deal more. These fluctuations in weight were due largely to the amount of rain that fell during the preceding month and to the extent to which evaporation had gone on.

The amount of nitrogen was reduced from 48 to 36 pounds. In the case of the protected manure we found that the amount of nitrogen was reduced from 48 to 42 pounds. The loss of nitrogen in the exposed manure is equivalent to 25 per cent of the total nitrogen present, as against a loss of nitrogen in the protected manure equivalent to 13 per cent of the total nitrogen present. So that during the first month we notice that with the exposed manure there was practically double the loss in nitrogen and almost double the loss in organic matter, as compared with the loss in protected manure.

In phosphoric acid there were 25 pounds to start with; at the end of one month, according to our analysis, 20 pounds, in round numbers, of phosphoric acid were present. This shows a loss that must have resulted from leaching, in spite

of the fact that there was a practically liquid-tight floor, consisting of double boarding laid crosswise. It is therefore evident that the flooring was absorbent. The rains falling upon the manure washed out the soluble portions of the manure, which were absorbed by the wood or leaked out between the boards. We cannot, therefore, consider a wooden floor as an absolute preventive to leaching from manure, and I came to the conclusion from this investigation that in order to prevent the loss of certain constituents it would be necessary to have a concrete or cement floor. Practically, as we saw, there were no losses in phosphoric acid or potash in the covered manure, but in the exposed manure during the first month between 15 and 20 per cent of the phosphoric acid disappeared. Consequently, we only have 12 pounds available of phosphoric acid in this exposed pen as against 22 pounds in the covered at the end of one month. Now it did not appear that after the first month there was any further loss, that is any appreciable loss, in this matter of phosphoric acid. It seemed as if this constituent remained pretty fairly constant after the first month. I account for that in this way. It would only be the phosphoric acid soluble in water that would be leached away. It was in the first month of rotting that this conversion from insoluble to soluble phosphoric acid largely took place, and it was this converted or soluble phosphoric acid that was leached away. Consequently, it was the more valuable portion of the phosphoric acid that was lost. The value of phosphoric acid in commercial fertilizers is dependent upon the form or combination in which it exists, insoluble phosphoric acid is only worth two cents per pound, but soluble phosphoric acid is worth six cents per pound. This loss of 20 per cent in this experiment does not represent the lower-price phosphoric acid, but represents that which was soluble and valuable as food for crops, and consequently worth six cents per pound. The amount of phosphoric acid rendered available is considerably less than in the covered manure, or if there had been as great a conversion the resulting soluble phosphoric acid had leached out.

While there was no loss of potash in keeping the manure under cover, there was a loss of 20 pounds, or 33 per cent, in the first month by leaching in the exposed manure. This is worthy of note—one-third of the potash lost by leaching during the first month's rotting, in spite of the fact that the flooring was thought to be practically water-tight.

At the end of three months the organic matter of this exposed manure was reduced to 790 pounds. This is equivalent to a loss of 60 per cent of the organic matter as against 55 per cent in the covered manure in the same period. The nitrogen during the first three months was reduced from 48 pounds to 34 pounds. This disappearance of 14 pounds is equivalent to a loss of about 29 per cent of the total nitrogen present, as against a loss of 18 per cent during the same period in the covered manure. That is an important matter for nitrogen, as I have said, is the most costly element of manure, and I may therefore repeat that we find during the first three months, the time when fermentation is most active, there was a loss of 29 per cent in the exposed as against 18 per cent in the covered manure. At the end of six months the total weight was 4,124 pounds, that is, it was really 125 pounds heavier than at the end of three months. This increase is, of course, due to the added water from the rain. The organic matter amounted to 652 pounds, showing a reduction in six months of 1,286 pounds, stated otherwise 1,286 pounds of organic matter had been used up by micro-organisms or germs in the fermentation. This represents a loss of 66 per cent of the total organic matter originally present. For the same period in the covered manure we had a loss of 59 per cent, so there is a tendency to equalize the loss in the covered and exposed manures as fermentation advances. During the first three months there was almost double the loss of organic matter in the exposed as in

the covered, 26 per cent in the covered, as against 44 per cent in the exposed manure.

At the end of twelve months the weight of organic matter was 607 pounds. That means a loss of 1,331 pounds of organic matter in the four tons of manure, which is equivalent, practically, to 70 per cent of the organic matter originally present. At the end of twelve months in the covered manure we find there had been a loss of 1,160 pounds, or practically 60 per cent of the original matter present, showing that taking it over the whole experimental period of one year there was a greater loss, by 10 per cent, in the organic matter in the exposed manure than in the manure that was covered. During the first six months the loss, as we have seen, was very much greater in the exposed manure.

The nitrogen during the twelve months' rotting was reduced from 48 pounds to 31 pounds. In the case of the protected manure the weight was reduced from 48 to 37½ pounds. This shows a loss in the exposed manure of 17 pounds, or about 36 per cent of the amount originally present, as against a loss of 10½ pounds in the covered, which is equivalent to 22 per cent during the same period. There is, therefore, the difference between 22 per cent and 36 per cent, or 14 per cent in favour of the covered manure in regard to this costly element. The phosphoric acid lost by leaching under the conditions observed was between 3 and 3½ pounds, or about 12 per cent of the total phosphoric acid. In available phosphoric acid there remained, at the expiration of twelve months, 16½ pounds as against 18½ in the covered manure. The loss, you see, although apparent is not considerable in the case of phosphoric acid. The most serious loss was in potash. During twelve months 24 pounds of potash were lost; it was reduced from 61 pounds to 37. These 24 pounds represent 40 per cent of the original potash which was lost by leaching, and this in spite of the fact that the bin was well constructed.

By the Chairman :

Q. Would a concrete bin have avoided that ?

A. I think so ; it would have been non-absorbent. I do not think it is possible to preserve manure under such conditions as we did, that is to say, with a board floor, without loss in potash.

By Mr. Rutherford :

Q. The location of the samples would affect the result. Possibly a sample at the bottom of the bin would contain more potash than at the top ?

A. It would. We took a great deal of pains to well mix the whole mass before sampling, but we recognize that there were almost insurmountable difficulties in getting a truly representative sample. Manure is an exceedingly complex material. It consists of litter, solid and liquid matter, and to obtain a sample for analysis which would thoroughly represent the mass of eight tons is a matter which requires a large amount of labour, and with the precautions that were taken, I can only hope that we came somewhat near the truth. The figures contained in our tables of data do not all fall into line, because of the fact that we have multiplied the percentages into the weights obtained, month by month, in order to ascertain the total amounts of the constituents present. You can readily understand that a small error in the analysis, or in the weighing of these manures, would result in a considerable error when calculated on the whole mass; but nevertheless the whole of the work has been done, I am assured, with sufficient care and the figures are such that I have no doubt the general results are correct. But the difficulty in thoroughly sampling the manure, the unavoidable though slight errors of analysis and any small inaccuracies in the weighings would necessarily affect these resultant

figures somewhat. This is only what might be expected. The general trend of the results, however, is so apparent that one cannot miss seeing the conclusions that are to be drawn.

By Mr. McLennan :

Q. Some farmers are in the habit of laying a flooring in their manure sheds of earth and muck in order to retain this liquid manure. What would the value of that be as a fertilizer ?

A. It would be very rich indeed. The use of peat or dry muck I have advocated for this purpose for years. It is an excellent absorbent and holds in a way that does not allow of dissipation these fertilizing constituents, more especially the soluble nitrogen and potash of the manure.

By Mr. Stenson :

Q. In what way do you look upon sawdust as an absorbent ?

A. Dry sawdust is an excellent absorbent. It is rather a dangerous material however in the manure pile on account of it being porous. It is difficult without taking special precautions to check the fermentation of such manure. It is well recognized, that although we wish to induce fermentation in order to render valuable certain elements of plant food, yet we wish to have that fermentation well under control, because excessive fermentation leads to the dissipation of valuable constituents (organic matter and nitrogen), and there is difficulty in doing so when you use sawdust. Unless the manure is kept compact so as to exclude the air and unless it is kept moist, it being very porous, the air permeates the whole mass and fermentation is so excessive that the greater part of the nitrogen disappears as ammonia It is a better absorbent therefore for cow manure than for horse manure.

Q. Is the introduction of sawdust itself into the soil beneficial ?

A. That all depends on the character of the soil. If it were a heavy clay soil I should imagine that it might be beneficial, but I would not advise the application of sawdust manure to a light sandy soil.

FERMENTATION OF MANURE WITH AND WITHOUT GYPSUM.

The second series of investigations in this matter of preservation were also with horse and cow manure mixed in equal proportions. Three tons were allowed to ferment *per se*, without the addition of any preservative and an equal weight of the same manure was mixed with gypsum or plaster Paris at the rate of 50 pounds per ton. Both of these lots were fermented inside a small building which I have illustrated in a photograph (now exhibited) and exactly under the same conditions of moisture and temperature. These manures were put in separate bins in this covered shed on the 15th July, 1897, and they were allowed to remain untouched, that is, they were not stirred or disturbed until the 15th November of the same year, when they were weighed and samples taken for analysis. I should mention, however, that from time to time these manures were moistened, because we thought that there would be less loss of nitrogen if the fermentation were checked by the presence of moisture, but as we moistened, as far as was practicable, both lots of manure alike, the conditions of both were similar. The object of this experiment was to ascertain if the presence of gypsum prevented the loss of nitrogen which, as we have seen, resulted when manure was preserved under cover as well as that exposed in an open bin or box. We wished to learn if the gypsum would prevent this escape of nitrogen as ammonia—the chief form in which nitrogen is lost from

fermenting manure. By the action of gypsum or sulphate of lime the ammonia, or rather carbonate of ammonia, is converted into a non-volatile form known as sulphate of ammonia, and although the amount of nitrogen present as ammonia is not large we wished to learn if we could prevent its loss by the presence of gypsum. Omitting many of the analytical details, which will be published later on, we may to-day compare results.

In regard to organic matter there were in each experiment 1,470 pounds originally present. In that fermented or rotted with gypsum, at the rate of 50 pounds per ton, we find at the end of the experiment that there were 728 pounds. The difference, 742 pounds, had disappeared during the four months. This manure had not been disturbed or turned. The manure without the gypsum contained at the end of that period 680 pounds, so that there was a difference of about 50 pounds in favour of the manure fermented in the presence of gypsum. The fermentation had not been quite so excessive in regard to the destruction of the organic matter. Whether this was altogether due to the presence of gypsum I am not at this moment prepared to state, because it may be possible that it was partly due to the presence of more water and the greater exclusion of air. The amount of moisture present has very much to do with the degree of fermentation which follows. Passing on to the consideration of the nitrogen we notice that there were 34½ pounds in each lot as originally experimented with, each lot consisting of three tons of mixed manure. At the end of the experimental period, that with gypsum contained 31·6 and that without gypsum contained 31·4 pounds. The loss in each case was practically the same. This experiment, therefore, did not show that under the conditions of this investigation that there was any fixation of the nitrogen by the gypsum. The loss, however, was very small—only one pound nitrogen per ton of manure—and I am of the opinion that the plan was such that it was sufficiently effective without the addition of gypsum. There was very little loss by this method, which briefly I may point out was as follows:—We put the manure in a bin, under cover, made it as compact as possible and kept it damp. Under these conditions we found the loss in nitrogen with and without gypsum practically identical.

By the Chairman :

Q. In other words, gypsum was no benefit?

A. Under the conditions of our experiment it apparently had no effect.

With regard to phosphoric acid we found that the available phosphoric acid had been increased from 12·6 pounds to 18·6 pounds with gypsum and that without gypsum to 17 pounds. These figures are so close that I do not attribute the difference in favour of the former to the presence of gypsum.

We may now discuss the amounts and condition of the potash present, with and without gypsum. We began with 69 pounds of total potash in each lot. At the close of the experiment that fermented with gypsum contained 55½ pounds, and that without gypsum 57 pounds. Here again the difference is so small that we may say there is practically the same quantity in each lot. The presence of gypsum probably had little if any influence upon the potash contained. We did not expect it would have, but the point to be remembered in this matter, is, that there was a loss of about 14 pounds of potash from each of these manures, namely, from the three tons which were fermented under cover. I account for that loss in this way:—From time to time we watered the manures in order to keep them moist, and there can be no doubt that the continual moistening of this manure from the top had the tendency to leach out a proportion of the potash which was gradually absorbed by the flooring or passed away through the cracks between the floor boards. Potash

is so easily soluble that we thus lost 14 pounds out of 70. I am going to continue this investigation of the preservation of the manure, altering the conditions somewhat in order to ascertain if their loss can be avoided.

Speaking of losses from leaching of manure, I have some photographs here taken on a farm not far from this city. The farmer has drawn a large amount of manure and stacked it in his yard, making a pile six or seven feet high. In front of it there was a pool, or small lake, in fact, on which one might float a rowboat. The loss from this treatment of manure or lack of care must have been excessive. (Photograph exhibited.) The greater part of the potash, instead of being in the manure was in this pond, and a considerable proportion of the soluble nitrogen also. That pond consisted entirely of the drainage or leachings formed by rain that has fallen on the manure. It sank into the ground and the farmer never recovered it.

By Mr. Stenson :

Q. Am I correct in stating that green manure is more valuable than rotted except on very light soils, that is general results?

A. Yes, on heavy soils I should advocate the use of green manure and should advise getting it into the soil at once, more especially if the farmer has no means of protecting it during fermentation.

Q. And loses less of its fertilizing elements under cover than when rotted in the open air?

A. Yes.

Q. What is the value of clover ploughed under, compared with the application of green barn-yard manure of equal weight ? Suppose there is a crop of clover on the land and you plough it in, what is the value of that as a fertilizer, compared with an equal weight of barn-yard manure?

A. That is a very important question. It is necessary to understand what that question involves. In the first place, the clover has taken from the soil phosphoric acid and potash. Its nitrogen, for the most part, we may suppose it has taken from the atmosphere. There is a clear gain, therefore, as regards this nitrogen. Now, the nitrogen in a clover crop over an acre would be equal to the nitrogen contained in from 10 to 15 tons of good average barn-yard manure. That 10 or 15 tons of manure would, however, contain, in addition to nitrogen, a certain quantity of phosphoric acid and potash, which would be a distinct gain to the soil, whereas in ploughing down clover we are only adding, as regards these two latter constituents, what we have already taken from the soil. An important point to remember in this connection is that we must consider of value any method or plan which converts material from a less soluble to a more soluble form. The clover during its growth has not added to the soil's store of mineral elements, but it has appropriated phosphoric acid and potash from the earth. Now, by the rotting of the clover in the soil this phosphoric acid and potash are liberated in more soluble forms, so that they can readily be used by succeeding grain crops. The clover, therefore, has done a considerable amount of valuable work in this process of conversion, but it is difficult to give you the corresponding value of this work in dollars and cents. But if you were to ask me about the matter of nitrogen, we could say that there we have a distinct and clear gain, because clover takes its nitrogen 1 argely from the atmosphere and consequntely is a gift, as it were.

By Mr. Stenson :

Q. Is there not another advantage in connection with clover by reason of the roots going deeply into the ground and taking the matter from that portion of the soil which does not give this nourishment to the ordinary plant which goes less deeply into the ground?

A. Yes, it is a deep-rooted plant and undoubtedly brings up mineral matter from the lower layers of the soil and the sub-soil. Large amounts comparatively of mineral food may thus be obtained. The rotting of these roots in the upper layers of the soil increases the fertility of the surface soil.

By Mr. Rutherford :

Q. I think the experiments we have had explained to us here are very valuable in their way, but it seems to me from a practical point of view that they lack. If ordinary manure with the same proportion of liquid in it as that which formed the subject of this experiment were put in a covered shed and left there a great deal of it would burn from want of moisture. There is no farmer who can turn his manure once a month, or even less frequently, than that; manure kept under cover and kept dry almost invariably burns. What would be the proportion of these various ingredients in manure that had been heated and burned ?

A. A great portion of its nitrogen and organic matter would be lost.

Mr. CHAIRMAN:—I suppose this manure having no moisture added to it. would be what you call fire-fanged ?

Mr. RUTHERFORD:—Not the manure which he dealt with. If you turn your manure you prevent it burning.

By the Chairman :

Q. Did the fermentation occur uniformly throughout the mass ?

A. Long before we closed the experiments all fermentation had ceased and the whole of the material was homogenous and dry to the touch, so that it crumbled easily;it was not absolutely dry however, because it contained a fair percentage of water. The percentage of water was reduced from 68 to 40 per cent. It lost 20 per cent of the water during the whole year, gradually becoming dry until in October of the year in which the manure was put in, the percentage had fallen to 42 per cent, after which it dried out very little. I take it that the matter of turning it in the way we did it really had the effect of drying it and arresting the fermentation.

Mr. RUTHERFORD:—You can take manure treated as you treated it and it will be perfectly dry, it may be black almost like rich soil, rich in colour, but if you keep manure dry with just moisture in it to start the fermentation process it will fang and then it turns white and there is no strength in it. That would be what would happen to the ordinary farmer's manure if he put it in a shed and left it there.

Mr. CHAIRMAN:—That was on account of the mechanical condition. Every practical farmer knows that horse manure will fang in a pile, but if it is spread in a shed where cattle are tramping steadily and mixed with cattle manure and they tramp it over, the mechanical condition is that it is compacted and it prevents fire-fanging.

Mr. RUTHERFORD:—You are introducing another feature altogether.

Mr. CHAIRMAN:—We are speaking about it as it is on the farm. In addition to that the farmer who deals with box farming for his cattle has manure which is perfectly compact, and any practical man will tell you that it does not heat but is kept moist.

Mr. RUTHERFORD:—That is not what I am referring to at all. I am speaking of a shed in which the manure is put and left and where no cattle go.

Mr. SHUTT:—It must be kept compact, because the presence of air throughout the mass, if the right degree of moisture be present, causes fermentation which must be held in check. The first principles require that the mass should be kept compact so as to prevent the air from too freely permeating the mass of it.

Q. In Manitoba we find it almost impossible to get manure rotted. Mr. Bedford, on the Experimental Farm at Brandon, finds it necessary to put layers of snow on his manure in the winter time to get it rotted. It is not moist enough. In the summer time if it is left outside very often in a dry season you have the same difficulty.

A. We have to intelligently apply certain principles, and a plan that is suitable here might not be suitable in British Columbia or in the North-west, and what is the best plan for the former might not be the best for the latter.

In connection with the question of manuring by means of the clover crop, which we have been discussing, it is important that I should refer to the large addition to the soil of organic matter, which subsequently forms humus in the soil. Humus is a valuable constituent of soils and must be present in generous amounts before a soil will give its maximum product. This organic matter is entirely derived by the clover crop from the atmosphere.

SOIL INOCULATION FOR THE GROWTH OF CLOVERS.

You will remember, gentlemen, that in the annual reports of the Chemical Division for the last two years we have given some results as to the fertilizing constituents in clover, advocating the growth of clover with the grains, this clover to be subsequently ploughed under, thus enriching the soil in nitrogen and in assimilable forms of plant food. The reason we advocated the employment of clover for green mauuring is because clover belongs to a botanical family known as the Legumes, which solely have this property of appropriating or assimilating the free nitrogen of the atmosphere, building it up into their tissues. By subsequently ploughing under the crop we can utilize that nitrogen for the permanent enrichment of the soil. Further experiments have shown that such plants as clover, pease, beans, and so forth, do not appropriate this atmospheric nitrogen by means of their leaves, but by micro-organisms or germs, or bacteria which exist in nodules which reside on their roots or rootlets. The growth of these bacteria in these nodules helps the clover plant to absorb the nitrogen which exists in the air between the particles of the soil. That fact having been proved, it occurred to the practical mind of the German scientist that these germs might be used in the practice of every-day agriculture. The first work done was to take the soil from a field which had grown clover and spread it over a field in which it was wished to foster the more vigorous growth of clover. That, of course, was soil inoculation, because the clover field contained in large numbers bacteria or germs. These when introduced into the field experimented upon, at once took hold of the clover plants and assisted them in this matter of nitrogen appropriation.

By Mr. Rutherford :

Q. Has Mr. Bedford, the Superintendent of the Experimental Farm at Brandon, Manitoba, had an opportunity of trying this ?

A. Not yet.

Q. Because there is an impression among some people in Minnesota and Manitoba that it is owing to the absence of those microbes that clover will not grow, and not owing to the winter ?

A. In Germany on sandy soils upon which hitherto farmers were unable to grow clover, they have by inoculating the soil induced clover to grow. This method of soil inoculation is costly and cumbersome, and it therefore occurred to a German firm to prepare a pure culture from a soil which contained these germs, and to sell that culture in a transportable form so that the material could be readily and easily applied wherever desired. In these bottles, one of which I hold in my hand, we have this Nitragin—the name given to the culture of bacteria which exist, as I have said, in the nodules on the roots of the legumes. The firm referred to has prepared Nitragins from horse beans, clover, pease and beans, and other leguminous plants, so that there are now for sale 17 different cultures, or Nitragins from the various germs and which can be used to promote the growth of the members of the leguminous family. Last year I procured several of these Nitragins and experiments were made with them to ascertain their effect. These experiments were carried on in specially constructed pots. I tried four different cultures, but in two of them, the Alfalfa and the Vetches, the growth was so poor I did not complete the work. The results might have been misleading. But with the clover and the horse beans we concluded the investigation, the object of which was to ascertain if any increase of growth or assimilation of nitrogen resulted in the clover growing in soil inoculated with clover Nitragin as compared with clover growing in soil which had not received this material and consequently had not been so inoculated. Very briefly, our methods of treatment were these. Seed was sown in two pots of untreated soil. These constituted the check or blank pots. In two other pots the soil was moistened with a solution of the culture. That is the method known as soil inoculation. In two other pots clover seed was sown that had been soaked in a solution of the culture. That is the method known as seed inoculation. These are the two methods of inoculation advocated and it was desired to ascertain which of them was the more advantageous to follow. The results from these two plans as tried upon the continent have differed. The results of our experiments are tabulated in the annual report now in press. They are not extraordinary in character. We did not find that any very large differences in the assimilation of nitrogen occurred. But nevertheless we did find that there had been a certain beneficial effect both in the case of the soil inoculated experiments and in those in which the seed was inoculated. The photograph now exhibited shows this effect. The pots "D.D." were untreated; in the pots "E.E." the soil was inoculated, and in "F.F." the seed was inoculated. Pots "E.E." and "F.F." show more crop than "D.D." The same is true in the case of the horse beans. The same number of plants were grown in each of these pots. At the close of the experiment the plants were carefully taken up, weighed and analysed, and from the data so obtained we calculated the amounts of the various constituents (nitrogen, etc.) under these different methods of culture. We found in the case of the horse beans that there was a small but decided advantage from soil inoculation. The seed inoculation while not giving such marked results had nevertheless been beneficial in increasing growth. The weight of these products, which include stems and leaves and roots, are as fol-

lows:—In the case of the clovers, of which you have a photograph before you, in the untreated pots, the weight of the crop was 147 grammes. In the treated pots in which the soil was inoculated the weight was 163 grammes, and the weight of the crop where the seed was inoculated was 189 grammes. There was consequently a marked increase in the total weight of the crop in which the plants had been treated with this culture of nitragin.

By Mr. Sproule :

Q. Then the soil inoculation seemed to be the best?
A. It did in the case of the horse beans. In the experiments with horse beans we found ten plants in the untreated pots weighed 127 grammes, in the soil inoculated the weight was 227 grammes, and in the seed inoculated the ten plants weighed 157 grammes.

By Mr. Stenson :

Q. Did you use the same amount of this nitragin for the soil as for the seed?
A. The nitragin was diluted with a certain volume of water and the seed was soaked in it for two hours, then taken out and allowed to drain. The seed was then mixed with dry sand and sown.

By Mr. Rutherford :

Q. Was the soil sterilized before you began?
A. No.

Q. Then it is possible you had some of this germ?
A. Yes. Our method was adopted in order to get a knowledge of the facts tried under conditions that would prevail on ordinary farms. I may add that we find it exceedingly difficult to get soil on the Central Farm that will not grow clover. If I were sure that there were large areas in Canada that would not grow clover I would undertake to sterilize soil and conduct experiments with it. In fact, we may do it this year, but these experiments, the results of which I have now been giving you, show that the nitragin assisted the clover in soils that we may suppose contain to some degree the clover germs.

By the Chairman :

Q. Will you try that on the branch farms?
A. Yes, we are sending out nitragin to them this year. The nitragin I have here in these bottles I intend to use in my experiments this year on the Central Farm. Other samples have gone forward to branch farms to be tried. These will be used on small plots, not in pots.

Q. In the North-west you will have the effects on the soil there and a report on the local conditions?
A. Yes, and the same at Nappan, N.S. These bottles of nitragin cost 80 cents apiece and they are said to contain sufficient to inoculate one acre. These data that I have brought before you, give you our results on this subject to date, though I have only stated them briefly and in outline. I am led to consider the method as one of much promise, and I purpose this year pursuing the subject further. The results of one year may be modified by those obtained in the future.

By Mr. Rutherford :

Q. How is it in the case of foul weed seeds in barn-yard manure?
A. Of course, using green manure those seeds would grow. We may suppose that thorough rotting kills most of the weed seeds.

Q. Does the thorough rotting of manure kill most of those seeds?
A. I think it does. Thorough rotting of manure we may, at all events, safely say kills a large number of them, but I think before we can answer that question decisively we shall have to make some experiments.

Q. I think that would be a very valuable experiment.
A. It would, but it would require several experiments; seeds differ greatly with regard to vitality.

Q. Mustard seed and pennycress are weeds that are troubling us and if it were a certainty that the thorough rotting of manure would destroy the vitality of the seeds of these weeds it will be important for us to know it?

The CHAIRMAN :—Does your experience seem to justify a doubt?

Mr. RUTHERFORD :—Yes.

Mr. SHUTT :—It is so very hard to define what thorough rotting is. I am inclined to think, however, that rotting in which the temperature assumes a considerable height would destroy the vitality of a large number of weed seeds. Many seeds, however, are on the outside of the heap, and these would escape, and therefore rotting as usually carried on would not be an absolutely reliable plan for the destruction of all the weed seeds contained in the manure.

Having examined the preceding transcript of my evidence, I find it correct.

FRANK T. SHUTT,

Chief Chemist, Dominion Experimental Farms.